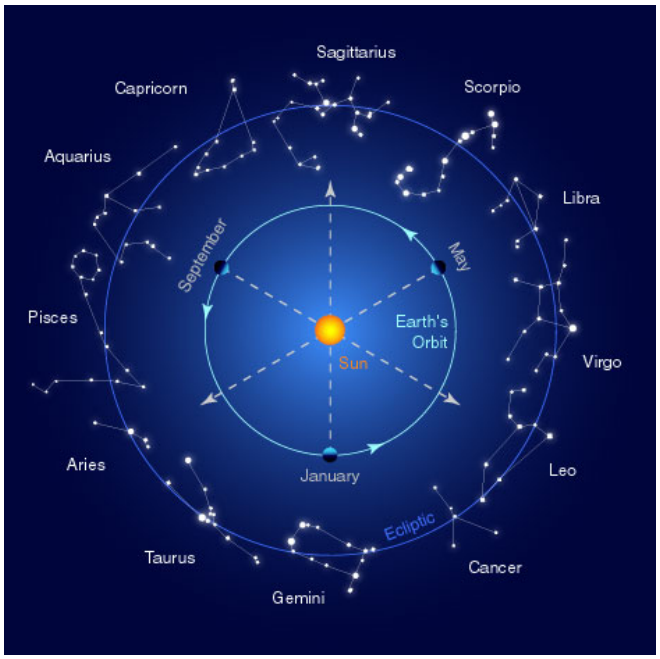
## 1.3: Motion of the Earth

As noted above, the constellations we see depend on the time of the year. As the Earth revolves around the Earth, it faces different directions in our galaxy. That is why we cannot see Orion in the northern hemispheric summer. The Northern Hemisphere is facing in the opposite direction of our celestial sphere. However, some constellations, most notably Ursa Major and Usra Minor, also known as the Big Dipper and the Little Dipper, appear to revolve around the celestial north pole, because their apparent location on the celestial sphere is close to that point. Likewise, in the Southern Hemisphere, the are constellations such as the Southern Cross that appear to revolve around the South Celestial Pole for the same reason.

Constellations like the Big Dipper, the Little Dipper, and Draco appear in the sky all year round and appear to revolve around the celestial north pole. "Draco" by JeaMY_Lee is licensed under CC BY-NC-SA 2.0

One group of constellations that many people find important are the twelve that lay right along the ecliptic. These are referred to as the **zodiac constellations**. Throughout the year, the Sun appears to “pass through” each of the constellations of zodiac. So, when someone says that are a “Libra,” that means they were born during the period of time when the Sun passes through the constellation of Libra. Note that when the Sun passes through as constellation, you cannot actually see it because it is “behind” the Sun and its light washes out the light from the stars of that constellation. The signs of the zodiac are used in astrology, the superstition that believes the stars can influence people’s personalities and fates.




The Constellations of the Zodiac are twelve constellations that lie on the ecliptic.

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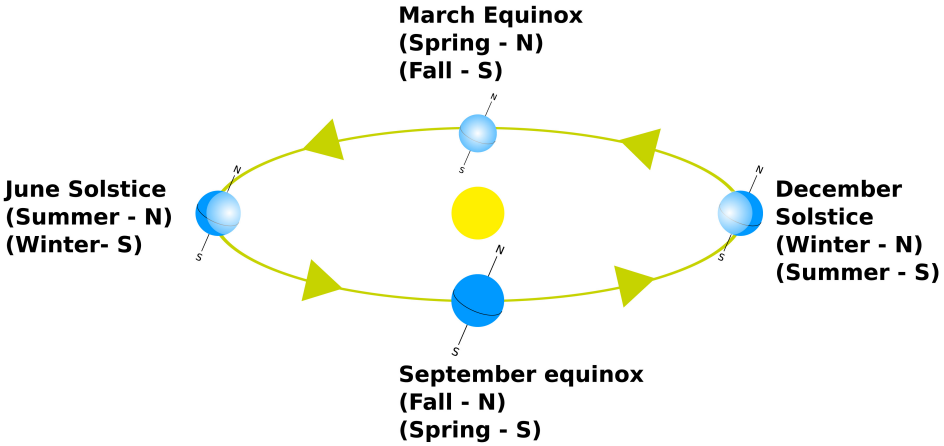
The Earth's motion around the Sun determines the seasons, but not in the way many people many assume. While the Earth's distance from the Sun does vary throughout the year, this is not what determines the seasons. Note that when it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere. In fact, during the norther hemispheric winter, the Earth is actually closer to the Sun than during the northern hemispheric summer. What determines the season is the 23.5 degree tilt in the Earth's axis of rotation with respect to the ecliptic. When the Northern point of the axial tilt is pointed toward the Sun, that hemisphere experiences summer while the Southern Hemisphere experiences winter and vice versa. Compared to when the axis is titled toward the Sun, when it is tilted away, that hemisphere receives less direct sunlight, the Sun's rays pas through a thicker portion of the Earth's atmosphere and the Sun's rays are also "spread out" over a wider surface area. For these reasons, that hemisphere that is currently titled away from the Sun receives less solar radiation per square meter. This results in colder temperatures compared to the summer months.



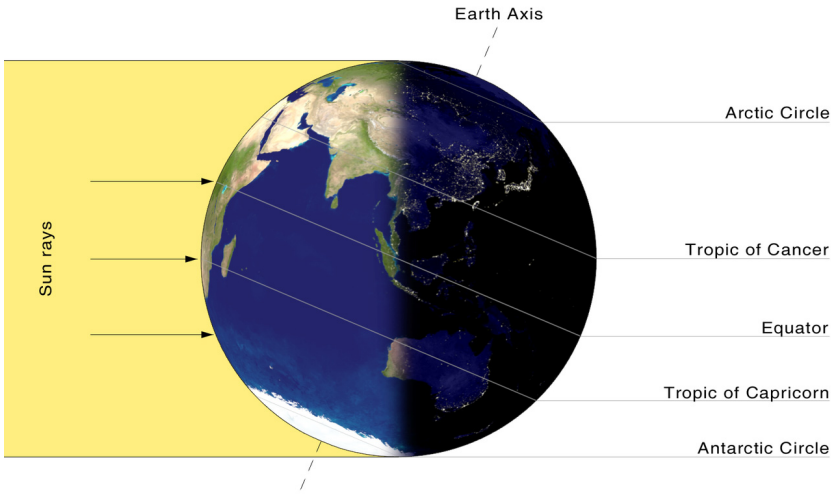

The solstices and equinoxes

"File:Orbital relations of the Solstice, Equinox & Intervening Seasons.svg" by Colivine is licensed under CC0 1.0

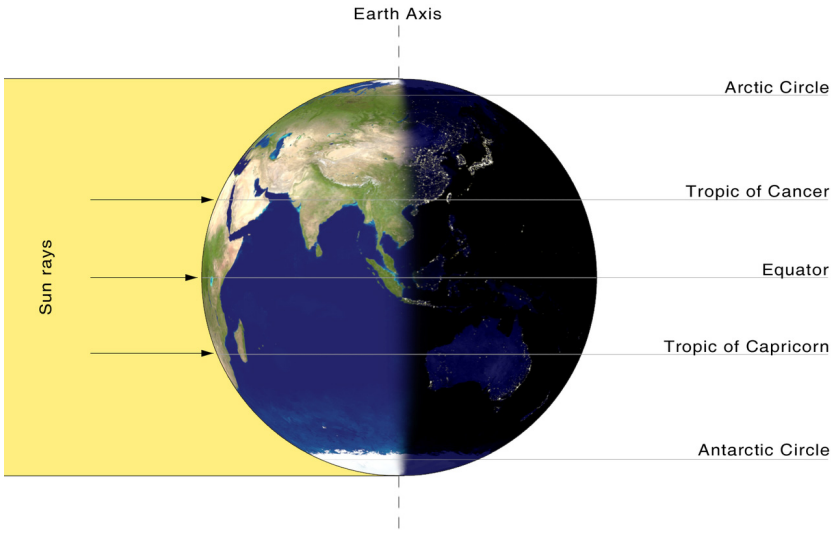
There are four important dates throughout the year with respect to the seasons. The first is the **winter solstice**. As the first official day of winter, the winter solstice is the point where the Sun stops moving lower in the sky. It is also the day with the shortest period

of daylight hours and the longest period of nighttime hours. The word “solstice” literally means “sun stops,” as in the Sun stops moving lower. After the winter solstice, the Sun starts reaching higher altitudes at noon each day and the amount of daylight time gets steadily longer until the **summer solstice**. This is the time when the Sun stops moving higher in the sky and starts reaching lower and lower maximum altitudes each day. The summer solstice is also the first official day of summer and marks the day with the longest period of daylight hours and the shortest period of nighttime hours. After the summer solstice, the daylight period gets short and shorter until the next winter solstice.

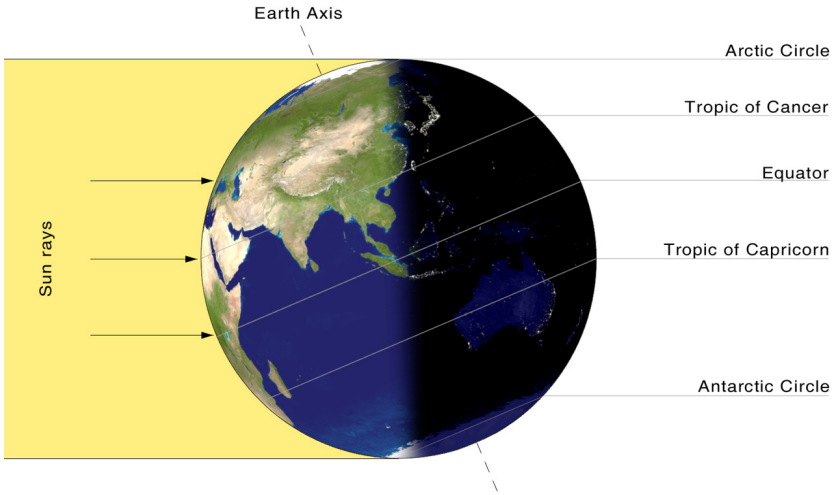
In between the winter solstice and the summer solstice are the equinoxes. The **vernal equinox** is the first official day of spring while the **autumnal equinox** is the first official day of fall. On both days, the Earth’s axis is pointed neither toward nor away from the Sun and the periods of daylight and nighttime are equal.




Axial Tilt During the Northern Winter Solstice. Image by Przemyslaw "Blueshade" Idzkiewicz.

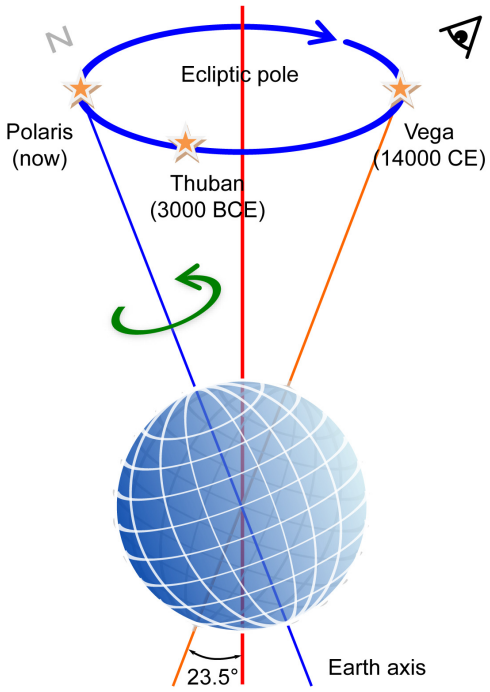



Axial Tilt During the Euquinoxes. Image by Przemyslaw "Blueshade" Idzkiewicz.




Axial Tilt During the Northern Summer Solstice. Image by Przemyslaw "Blueshade" Idzkiewicz.

Another important movement of the Earth is the precession of its axis. Over a period of about 26,000 years, the Earth's axis makes a complete circle, much like how the axis of a spinning top makes a circle as it slows down. As a result of precession, the direction of the axis shifts over time. Currently, the northern axis points in the general direct of the star Polaris, which is why it is always near the celestial north pole. This has made Polaris a handy tool for navigation and why it is called the North Star. However, 5,000 years ago, when the Egyptians were building the pyramids, the north axis was pointing toward a different star, Thuban. In the future, it will point toward other stars or toward no star at all. Currently, the southern axis is not pointing to any star, so there is no "South Star" that can be used for navigation below the equator.




 The Precession of the Earth's Axis



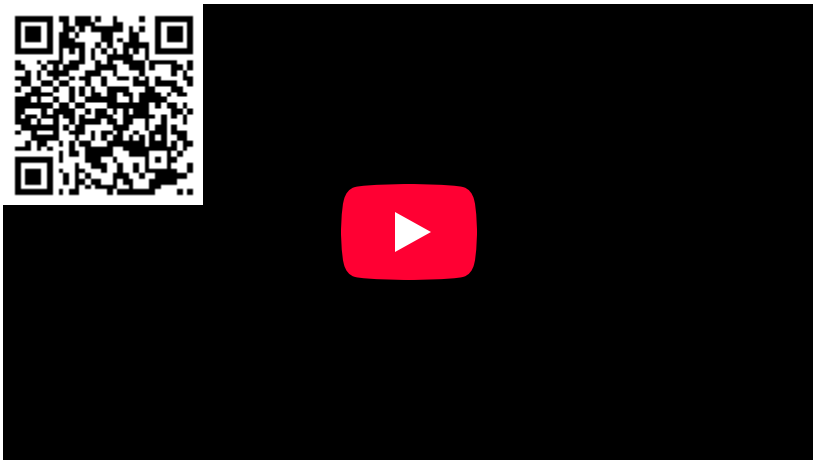
The Precession of the Earth's Axis is like a slowly spinning top.



Recall that ancient people used the sky to mark the passage of time, particularly from one year to the next. But is a year? That is harder to define as you might think and there are actually two different ways to define a year. A **sidereal year** measures one orbit of the Earth around the Sun relative to the constellations. On the other hand, a **tropical year** is measured using the seasons, such as from one vernal equinox to the next. Because of some slight differences in the Earth’s motion relative to each measurement, a sidereal year is about 20 minutes longer than a tropical year. This means that the appearances of the constellations are slowing

shifting over time. Currently, Orion is a winter constellation, but in 13,000 years, it will be a summer constellation, appearing in July and August even though those months, according the tropical year, will still be the northern summer.

Likewise, we have two different ways to measure a day. For example, we define a **solar day** as from noon to noon. However, because the Earth moves partially along its orbit, the stars are not in the same position in sky as they were at the same time as the previous day. Therefore, a **sidereal day**, which is measured from the position of the stars from night to night, is about 3.9 minutes shorter than a solar day.



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